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A GUIDE

IN THE

STUDY AND IMPROVEMENT OF PLANTS AND SEEDS

FOR

BOYS AND GIRLS

PREPARED BY
THE CANADIAN SEED GROWERS' ASSOCIATION
OTTAWA, CANADA

1905

SB 119
C3

A GUIDE

IN THE

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BOYS AND GIRLS

PREPARED BY
THE CANADIAN SEED GROWERS' ASSOCIATION, OTTAWA, ONT.,
AND PRINTED BY
THE DOMINION SEED BRANCH.

Experimental Farm, Ottawa, August 2. Strips of grain

PREFACE.

This circular has been prepared as a Guide for Boys and Girls in the Study and Improvement of Seeds and Plants. Owing to its relative importance among cultivated crops, and to the fact that it lends itself admirably to special investigation, the oat plant has been chosen for this study. What we may say about this plant as regards methods of improvement will apply equally to wheat and barley, but not to corn or potatoes, or to the grasses and clovers. Those interested in the scientific improvement of the four latter crops, as well as in a more comprehensive account of methods of improvement of oats, wheat and barley are referred to the booklet "The Canadian Seed Growers' Association and Its Work" (free on application to the Canadian Seed Growers' Association, Ottawa), and to the book "Plant Breeding in Scandinavia"—Newman (available at office of C. S. G. A. for $1 per copy). A list of other publications dealing with questions pertaining to plant improvement and soil culture will be found in the last pages of the former publication.

Part III of the present booklet has been prepared specially for teachers.

In schools where botany and allied subjects are taught it is usually the custom to study *wild* plants. Such plants possess striking flowers with clearly defined parts and are well suited to a botanical examination. Plants like oats, on the other hand, are seldom studied either from a botanical or a biological standpoint. One of the purposes of this pamphlet is to encourage a greater interest in this important plant. The fact that different oat plants taken from a field may differ very considerably in practical value and may mark the starting points of new and superior races or "strains" provides an attractive opportunity to engage in a most interesting and promising line of investigation. Such a study in rural schools, moreover, should help to arouse a new interest in farming and in farm life by demonstrating, among other things, that more profitable varieties are often obtainable right at our doors.

Realizing the great practical importance of propagating in Canada, only the best varieties and strains, the Dominion Government encouraged the organization of an association known as The Canadian Seed Growers' Association (in 1904). The membership of this association is composed of farmers who are following on their own farms a simple but systematic plan of seed selection as a means of providing themselves with the very highest yielding seed obtainable. A system of registration, or "pedigreeing," for selected seed has been worked out, which corresponds to some extent with the registration of live stock. Members who have seed coming up to a certain standard of perfection may have it "registered," so that it may go out in sealed sacks with the certificate tag attached. Such seed brings considerably higher prices than does ordinary seed.

The growing of registerable seed, at least to some extent, should receive the most careful consideration of practically every farmer. Those desiring further information on the subject should communicate with the Secretary, Canadian Seed Growers' Assóciation, Ottawa, Ontario.

THE STUDY AND IMPROVEMENT OF PLANTS AND SEED.

PART I.

THE SEED.

Every one has seen a grain of oats. It is very small and common-looking and you would never suspect that it contains a living plant, and yet it does. So long as the grain is kept in a dry place the little plant within it keeps on sleeping, but when placed in nice soft, moist soil, about two inches below the surface it quickly wakens up and begins to grow, bursting the covering of the kernel and sending out first a little white root stalk which is quickly followed by from two to four others. (See Fig. 1.) These penetrate into the earth and serve not only to hold the little plant in its place, but to draw up food in liquid form to nourish it and produce growth. Each of these little rootlets is partly covered with soft downy hairs which are feeding organs of the plant. A couple of days after the first appearance of the rootlets the little stem appears. (See 2 Fig. 1.) Unlike the roots which prefer the cool dark earth, the stem likes the light and therefore grows towards it and away from the soil.

An examination of an oat grain will show that it is made up of two main parts: the outer covering or hull and the main part or kernel in which is the germ or young plant. The hull serves to protect the kernel, but is of little value for food. An oat with a thick heavy hull is therefore not the best kind to grow.

VITALITY OF THE SEED.

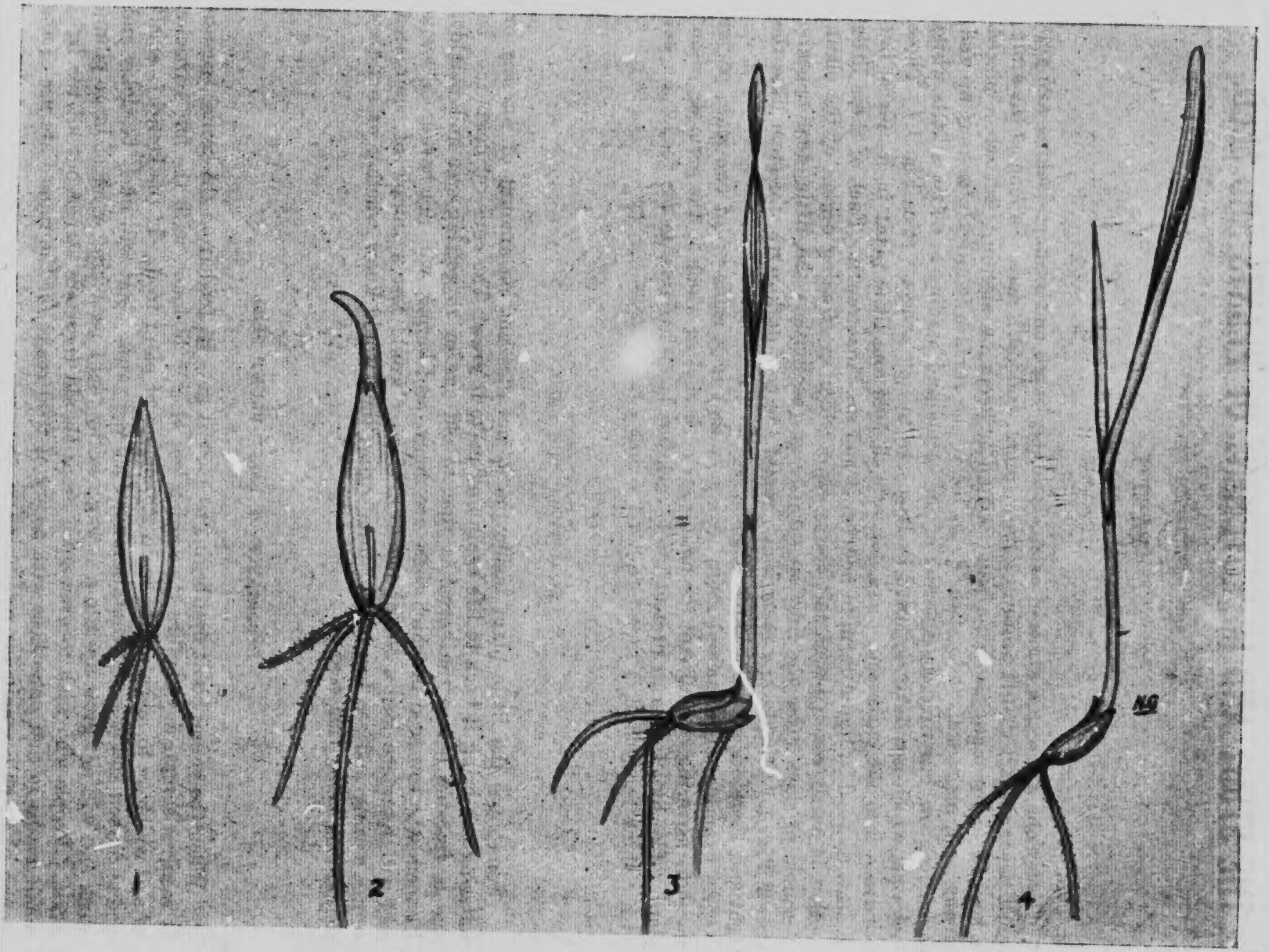
Sometimes the little plant inside the kernel dies and no amount of nursing or watering can bring it back to life again and make it grow. The cause of death may be due to freezing before the kernel is ripe, to old age or to getting wet and mouldy. Farmers who sow seed in which there are many dead kernels will not have good crops and will therefore lose a lot of money. If they would test a sample of their seed before sowing and see how much would grow, they would know whether or not they should risk using this seed.

IMPORTANCE OF LARGE PLUMP SEED.

When the young plant first begins to grow it gets its food from the kernel because it requires several days before the rootlets get closely in touch with the fine particles of soil which go to make up the main storehouse of plant food. If the kernel is small and shrunken and does not contain much food the young plant will likely be sickly and weak and will not grow up into a strong healthy plant producing a lot of large plump grain. People who wish to grow good crops should therefore screen out all the light small grains so that only those with plenty of food ready for the immediate use of the young plant will remain for seeding purposes.

Experiments have been conducted to find out how much more grain is produced from large plump seed than from small light seed and it has been found that the large plump seed gives a much larger and better crop.

Fig. I.



Four days' growth. Five days' growth. Eleven days' growth Sixteen days' growth.

PREPARATION OF THE SOIL.

To grow good crops the soil must be fine and mellow and must contain the necessary plant food. If it be hard, dry and lumpy, the plant food is "locked up" and the fine rootlets and root hairs are unable to secure enough to make the plant grow.

To be available for the use of the plant, this food must be dissolved gradually in water and acted upon chemically. A certain amount of water should therefore be held in the soil continually. The soil which is able to take up and hold water best is one which is in a fine condition and contains a large amount of vegetable matter. This is one reason why good crops are likely to be grown after an old sod or when a green crop such as rye or buckwheat is ploughed under and the soil worked up finely.

Too much water in the soil is very undesirable and is likely to prove fatal to our ordinary farm crops. An excess of water in the soil checks chemical and bacterial action, which action is necessary in the preparation of the plant food. If a soil be unable to rid itself naturally of the surplus water it will be necessary to dig drains and ditches for this purpose.

Good cultivation, proper drainage and enough plant food are the three essentials in successful soil culture.

VARIETIES OF OATS.

When we speak of a *variety* of oats we mean a kind which is different from every other kind in some one or more particular. There are many different varieties of oats. Some are white, some are black; some have branching heads while in others the grain is all ranged along one side of the head. (See Fig. II.) In some varieties the kernel is long and thin while in others it is short and thick. The hull or outer covering of the kernel in some varieties is much thicker than it is in others. Some varieties do best on heavy clay soil while other kinds seem to prefer a lighter and more sandy soil. Certain varieties seem better able to resist attacks of rust and smut than are others, and some have stronger straw than has the average variety and thus do not blow down so readily. Still other varieties mature earlier than our common sorts and are therefore popular for certain purposes such as for growing with barley.

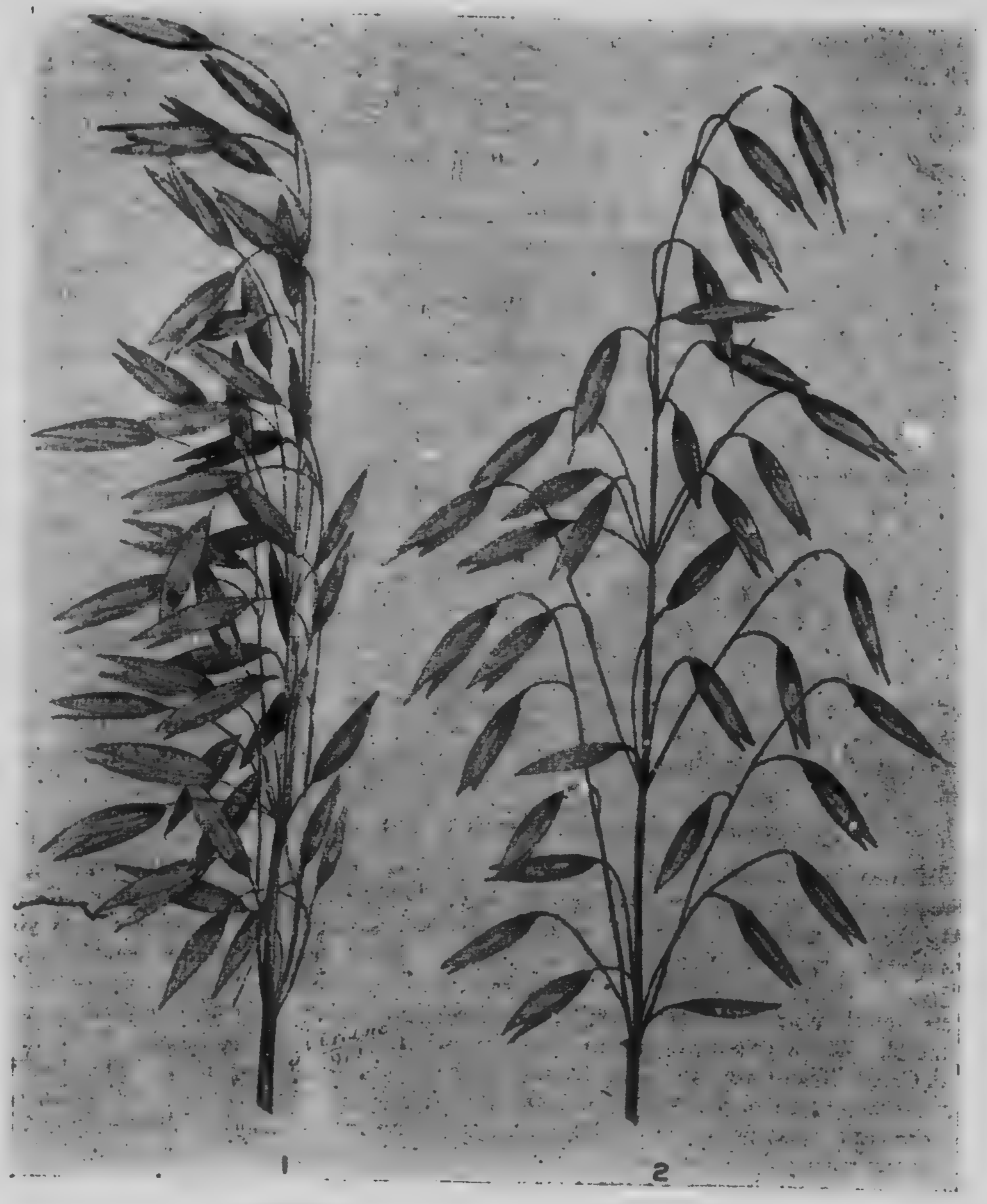
DIFFERENCE BETWEEN PLANTS IN THE SAME VARIETY.

While there are great differences between varieties, there are also differences between individual plants in the same variety. Were you to walk through a field of oats just before harvest time and examine carefully a number of different plants you would notice some of these differences. You would not find two plants exactly alike. Were you to pull up a number of plants, you would notice that in some cases 8 to 10 stems would be produced from a single seed while in others only two or three would be found. Differences in length and strength of straw, size of heads, etc., would also be noticed. There are two main reasons why all plants are not alike. The first is that the condition of the soil is not exactly alike in any two places; the second is that the seed which produces the different plants may have come from different strains within the variety. In this case the latter will have been what we call a *mixed* variety and not a *pure line.*

How a Variety of Oats may be Improved.

If certain plants in a variety of oats are better inherently than are others, improvement will depend upon our ability to select and propagate the best plants. A good deal may be accomplished in this direction by selecting and threshing out by hand a few

FIG. II.



Side Oats. Branching Oats.

pounds of mature heads from the most desirable looking plants. The cleaned seed obtained from these heads is then sown the following year on a plot by itself, where it is carefully watched during the growing season and any impurities removed. When the crop matures, a similar selection of heads is made for a seed plot the following year. By continuing this simple process year after year a marked improvement sometimes may be made. This is the system commonly practised by members of the Canadian Seed Growers' Association, as already intimated.

A second but more exacting method of selection is known as the *single plant* or *separate culture system.* This system aims to discover if possible a *single outstanding plant.* This *"mother"* plant then becomes the starting point for an improved "strain". In order to find such a plant it is necessary to choose quite a number of plants and sow the seed from each by itself in a small plot where a comparison may be made between the progeny of each mother. Such a study reveals the interesting fact that the most promising looking plants do not necessarily reproduce their outstanding qualities. It is only by carefully comparing the *progeny* of different plants that one can locate the best with any certainty.

This system requires too much time to be practicable for use by the average farmer. On the other hand it may often be carried on to advantage by boys and girls either on their home farms or in gardens provided at schools. For the sake of convenience, the following plan of proceedure is recommended:

PART II.

SEPARATE CULTURE SYSTEM OF SEED IMPROVEMENT.

THE FIRST YEAR'S WORK.

Before harvest obtain permission to select a number of plants—say, two or three dozen—from an ordinary oat field. When the crop is ready to cut go through the field and select plants which appear to be superior to others. Pull these up by the roots carefully and carry them to a convenient place for further examination.

The sort of plant to select may be described as follows:—

(*a*) One which is quite tall and able to stand up well.

(*b*) One which produces stems all of about the same height and not a lot of short, weak stems.

(*c*) One in which the heads on the different stems all ripen about the same time.

(*d*) One which is free from rust and smut.

(*e*) One in which the yield of large, plump grains is high.

Shake off the earth from the roots of the selected plants and lay the plants on the ground side by side for further study and comparison.

Choose twelve of the best of these. The seed from each of these twelve selected plants should be threshed and cleaned separately and each lot kept by itself. Examine carefully the twelve lots of seed and pick out the six best lots for seeding purposes, discarding the others.

Lay these six lots of seed away in a place proof against vermin.

THE SECOND YEAR'S WORK.

(1) Six small plots will be required for the second year's study.

(2) Each of these plots is to be sown with seed from one of the six lots of seed laid aside last year.

(3) The size of each plot will depend upon the amount of seed contained in each lot. A plot 3 feet square will usually be large enough to accomodate the seed from any one plant.

(4) Make drills about 1 inch deep and 6 inches apart on each plot and drop the grains about 3 inches apart in the drills. Cover the seed carefully so as not to disturb the planted grains.

(5) Careful notes should be made from day to day on the performance of each plot during the growing season and the same recorded.

(6) Examine the production of each of the six plots and pick out two or three which appear to be the best.

(7) Gather the heads produced on each of these plots in a sack by themselves and thresh them out by pounding the sacks with a stick.

(8) The chaff and light grains can be blown out by the wind.

THE THIRD YEAR'S WORK.

The third year's work consists mainly in comparing the crop produced from seed taken from the two or three selected plots of last year and deciding which is the best. An extra plot sown with seed from the original sample should also be grown.

1. Three or four plots will be required this year.
2. The size of these plots may be decided by the amount of cleaned seed on hand. Plots 9 feet long by 3 feet wide will be found a convenient size and should be large enough in most cases.
3. Two or three of the plots are to be sown with the seed secured from the best plots of last year. The other plot is to be sown with seed from the original sample which was laid aside for this purpose when the work was begun.
4. The seed may be sown in the same way as that recommended last year or it may be scattered over the surface and carefully worked into the soil with an iron rake.

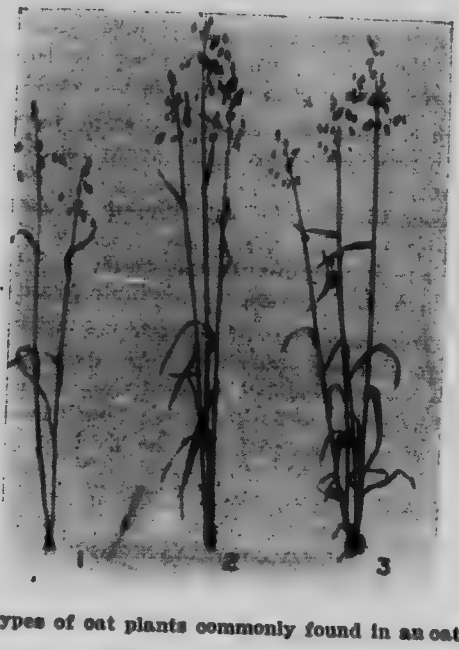


FIG. III.—Types of oat plants commonly found in an oat field.

The plant in the centre is plainly the best. Note the strong, even growth of this plant.

5. Notes on the length, strength and general character of the plants should be taken during the growing season and this information, together with such other information as may be gathered, should be recorded.

6. After examining the plots carefully and noticing any differences, especially between the plots sown with the selected seed and the plot sown with the unselected seed, choose the best plot and discard the others.

7. Gather all the good heads from the good plants on this plot, place them in a sack and thresh them out in the same way as last year.

8. The cleaned sample may then be sown on the farm, the following year.

If kept pure and carefully handled for a year or two, enough good seed can be produced to sow a large area. Such seed furthermore may be accepted for registration by the Canadian Seed Growers' Association as "Registered Seed." This class of seed is in good demand, which fact provides an excellent opportunity for the boy to take up the production of registered seed on his home farm as a regular branch of farm work after his school days are over.

PART III.

FOR THE TEACHER.

In Parts I and II of this circular an attempt has been made to arouse a deeper interest amongst boys and girls at school and the young people at home in the study and improvement of plants, by putting them in possession of certain fundamental truths relating to plant growth and improvement in the first place, and in the second place by indicating a series of observations and experiments to be carried on during the growing season. We have endeavoured to eliminate all unnecessary details and have aimed at giving a clear and concise statement of the essential points to be observed in carrying on the work so that any earnest and intelligent person might engage in it with every hope of achieving success.

The success or failure of work undertaken at the school depends in a large measure upon the attitude of the teacher in charge. While it should be clearly understood at the outset that the work outlined is to be performed by the boys and girls themselves, it is of the greatest importance that the teacher should advise and encourage them by entering heartily into the work with them. It cannot then be said by anyone that an additional burden has been laid upon the already overburdened teachers, but instead, if undertaken in the right spirit this work will become a source of pleasurable recreation, opening up to both pupils and teachers new avenues of interest and affording opportunities for engaging in new and profitable lines of study which must surely result in the improvement of crops and in the betterment of the community.

In this study of nature and nature's inscrutable processes the discerning teacher will see much more than the improvement of seed and the cultivation of crops. She will witness the enobling of youth[illegible] ideals and the enrichment of youthful experiences all tending to produce in our you[illegible]d rising country those high moral standards and that righteousness which exalteth [illegible]tion.

The true teacher cannot but be interested in every movement that contributes to the welfare of the community in which she lives. Indeed such a teacher is possessed of those qualities and attainments that should make her a leader in the community and her school should be a centre of interest and of culture and therefore the pride of the people. The school of the past has been too little concerned with the life and welfare of the people at its doors. This circular represents an attempt to harmonize home and school interests along one line, viz., the improvement of one of our greatest cereals—the oat plant. It is our firm belief that if the boys of our schools became interested in the studies herein outlined and, under the direction of a capable teacher, carry out the instructions given they will not grow up to regard with disfavour the life and work of the farmer, but they will gladly take it up and carry it on more successfuly than if these school studies had never come up to start them to think and then to do.

SUGGESTIONS IN ORGANIZING AND CONDUCTING THE WORK.

As the work herein outlined will no doubt be new to many teachers, it has been deemed advisable to include in this part of the circular such suggestions and information as may be of use to teachers and others interested.

LOCATION OF THE PLOTS.

In locating the plots, the question of convenience and safety should be considered. Care should be taken not to encroach upon the space used by the pupils in their games. It is desirable, also, that the plots should be near enough to the public highway that they can be seen, and visitors should have access to them at all times during the day. They should not be in the shade of trees or outbuildings and they should be as nearly equal in quality and fertility of soil as possible and have equal exposure to sunlight.

PROTECTION OF THE PLOTS.

Nothing is more disheartening to boys and girls than to see the plots which they have made and planted with great care and expectation, destroyed through neglect or through inefficient protection. The teacher should see to it that the plots receive no injury from careless pupils or thoughtless visitors, from domestic fowl of neighbouring farmyards, from dogs or other animals that too often run at large and last, but not least, from the troublesome domestic sparrow.

HOW TO PREPARE AND USE POISON FOR SPARROWS.

Disolve one-eighth of an ounce of strychnine in one-half pint of boiling water and stir this into two quarts of wheat so as to moisten all the grain equally. Dry the wheat and scatter it about on the paths between the plots where the sparrows will get it. One such grain of wheat will kill a sparrow.

PREPARATION OF THE SOIL.

Unless the soil is already under cultivation, preparation for the spring planting should be begun in the autumn. If the ground is in sod it should be ploughed early in the fall and left over winter, and if the area to be used is very small, spading may take the place of ploughing. For subsequent fertilizing a load or two of stable manure should be brought and placed in a neat pile at one end of the garden enclosure, covered up with rough boards and left over summer to be used the following spring. It will then be thoroughly rotted and will not, as is frequently the case with raw manure, add weed seeds to the garden.

In the spring, as soon as the soil is dry enough to crumble after being compressed by the hand, it should be thoroughly pulverized with the disc and drag harrows and at the same time made as level as possible. If the soil has a large percentage of clay, it should not be worked too soon after rain. The sods should be picked off and thrown beside the manure pile. If some manure is mixed with them and they are left to rot excellent material for potting plants or for window boxes for flowers will be the result. All sticks and stones should be removed and the latter used to fill up holes around the fences, whilst the former, with all weeds and dead plants, should be burned. If wood be used as fuel in the school scatter the ashes evenly over the plots before spading them up in the spring. Good drainage is very important and if there be no good natural drainage the trustees should put in an underground drain of tiles. If the garden is not more than forty feet wide a single row of four-inch tile down the centre, about three feet below the surface and leading to an outlet may be sufficient.

The size of the garden will depend upon the number of pupils, the space available and the amount of work undertaken. The use to which the garden is put is of greater importance than mere size. In every case it should be definitely marked out and corner posts driven down. No grass or weeds should be allowed to grow inside these boundary lines. If coal be used for fuel in the school the ashes may be utilized for making cinder paths.

PLANNING AND PREPARING THE PLOTS.

Read again Part II of this circular and note the number and size of the plots called for each year. The accompanying diagram (Fig. IV), which has been drawn to a scale (one inch equal to 10 feet), represents an arrangement which should be suitable for most school grounds. Once the plots are laid out according to this plan, it should not be necessary to change the location from year to year.

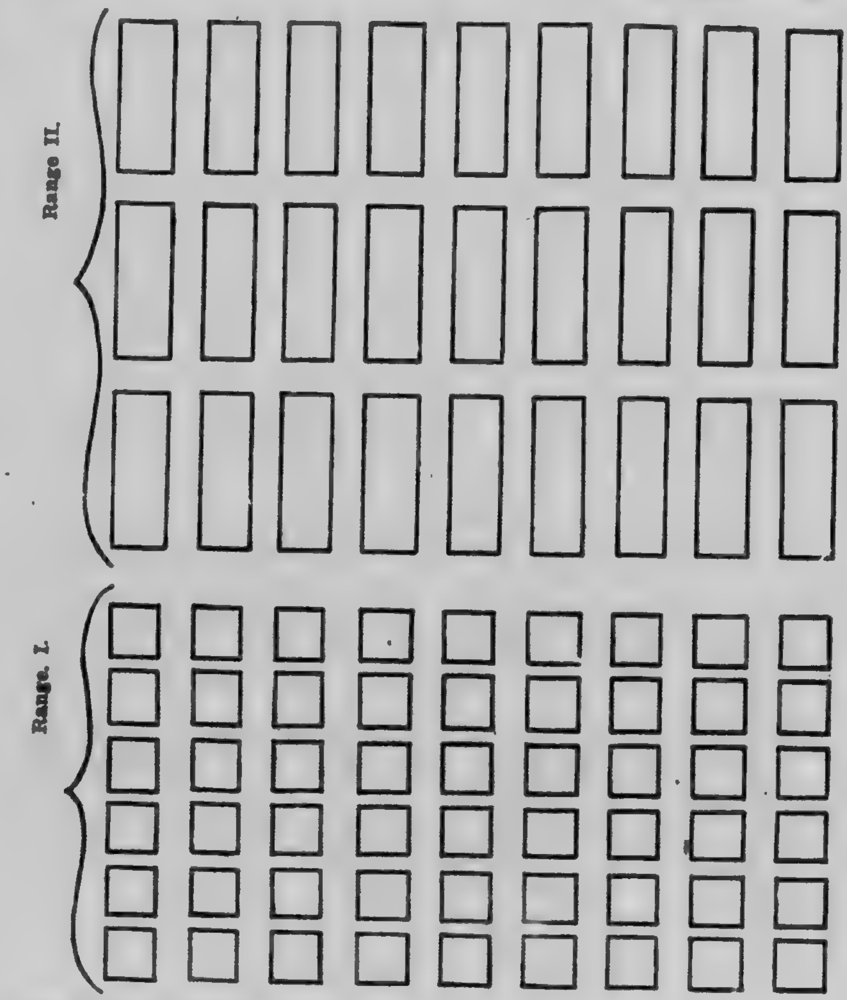


FIG. IV.—Diagram showing arrangement of plots for eighteen pupils—9 new beginners on Range I and nine second year operators on Range II.

The paths and the main walks should be a few inches lower than the plots. This can be accomplished easily by skimming an inch or two off the soil from the walks and putting it on the plots. This will also help to make the walks more even and level. Measure the plots and paths accurately and drive down small pegs one inch square and one foot long at the corners of the plots. Plots so measured and made uniform in height and kept in perfect line are most pleasing to the eye and besides, work done in this way is not without its value as a training in neatness and thoroughness. When the walks have once been established they should not be torn up again, the plots being cultivated altogether by hand. Horses will not be required in cultivating the garden after the first season.

PLANTING THE PLOTS.

The planting of seeds in the school garden is one of the most delightful of exercises. Planting day should partake of the nature of a celebration and special preparations should be made for it. It is not wise to attempt to prepare and plant the plots on the same day. To ensure satisfactory results the seeds must be carefully planted. The teacher should make sure that each pupil knows exactly what he is expected to do before going into the garden to plant; then it will be easy to direct and supervise the planting. By means of a strong line stretched across a whole row of plots which are being operated by the different pupils, the seed can be put in in drills that will be perfectly straight and when the grain comes up will give a very pleasing effect. If possible the drills should run north and south as this allows a more even distribution of sunlight. Use a yard stick or measuring rod in order to get the rows all the same distance apart. In addition to the tight line an inch board at least 6 inches wide with straight edges, will be found useful as a straight-edge in making the drills and the pupils can also walk out on it when planting the seeds. It can also be used to firm the soil after the seeds are covered.

Each p[illegible]uld have a wooden label bearing the name of the owner and the name of th[illegible]ty of oats under cultivation. All labels should be placed at the end of the plots [illegible]est the public highway and should be in line with each other.

WATERING.

If watering is done it should be done in the evening and not when the sun is beaming down upon the plots. Watering the plots thoroughly the day before planting is a good practice. In most cases, however, it is best to cultivate the soil thoroughly and let nature do the watering, except in cases of drought.

WEEDS.

All weeds should be removed from the garden and the paths kept neat and trim. Each pupil should be held responsible for the condition of his own plot or plots and half the paths immediately surrounding them.

Care should be taken to see that each pupil knows the name of every weed he pulls. He should also know whether they are annuals, biennials or perennials, and how they are most easily eradicated in ordinary farm practice. In this work the teacher will find the Dominion and Provincial Government bulletins very useful.

GARDEN TOOLS AND EQUIPMENT.

It is not absolutely necessary to incur any expense for garden tools in beginning the garden work as the pupils will be willing to bring the necessary tools from home. It is to be hoped, however, that this work will so commend itself to the provincial authorities and to the ratepayers that sufficient financial support will be given to allow of the purchase of desirable equipment. We believe that at no very distant date, rakes and hoes will be considered as much a part of the school equipment as crayons and blackboards are now.

Tools should be of good quality, being light and strong. Get ten-tooth steel rakes and six-inch boys' hoes, a few light spades, a couple of small digging forks and a couple of D-handled shovels. Have a tape line, if possible, showing the English measures on one side and the French or metric system on the other. Mention has already been made of the garden line and it will be found most convenient to have it on an iron reel. A small-sized reaping hook will be handy in cutting the grain from the plots, and a light wheelbarrow will be in constant demand.

NOTE BOOKS AND GARDEN RECORDS.

Accurate records have a double value. In themselves they are an evidence of good work done and are also of interest and value for future reference and comparison. Such records moreover demand accuracy and thoroughness in observation on the part of the pupil and therefore have considerable training value. Any common note book will do for making entries from day to day during the season and the pupils should be encouraged to make a note of everything that bears either directly or indirectly upon the garden work. It is important that the dates should be given for all work done and for important observations. These first records should be made with a good deal of attention to detail and then at the last of the season they can be written with pen and ink in a more permanent record book. Some of the less important or perhaps faulty observations may then be omitted.

In addition to the data called for in Part II of this circular in connection with the yearly report sheet, the student's record book might contain the following: A plan of the school grounds, showing the location of the plots, the school building, trees, walks, public highways, etc.; the nature of the soil and sub-soil; when this ground was first cleared and cultivated; what used for and who the first owner was; what drainage facilities it offers, natural and artificial; the method of cultivation used in preparing it for the grain plots; the kind of fertilizer used, if any; the date when the first work was done in the spring; the weather conditions that prevailed during the growing season and the influence on the germination and growth of the grain; the amount of rainfall for the season; the occurrence of frost, if any; the appearance of the oat plant at different dates (illustrated by drawings); the heading out and ripening; special qualities sought in selected plants; the yield per acre; exhibitions held and prizes won; suggestions as to how the work might be improved another year.

The loose leaf book such as is now being used in many schools, has some advantages for record purposes. Fillers of different kinds of paper ruled for essay work and plain for drawing and painting can be bought to suit the covers, or the pupils can make covers out of heavy paper, and decorate them with ink or colour drawings. When the gardening season is over the records and illustrative drawings can be collected and arranged in suitable order in the covers and neatly tied with fancy cord or ribbon. These the pupils will be proud to own in after years. In all this work the pupils will be required to exercise care in their writing and drawing, in spelling and punctuation, and incidentally they will have some practical training in grammar and composition. This work will also be found to afford valuable exercise in the solving of many practical problems in arithmetic and mensuration so that when everything is considered it will be seen that many of the most valuable branches of study can be profitably associated with the cultivation of grain plots in the school or home garden.

RELATED STUDIES.

I.—Garden Studies.

In addition to the work already outlined there are a number of closely related studies that should be of interest to the pupils. In most cases it will be possible to include in the school garden a larger area than is actually required for the grain plots as shown in the plan on page 13. This reserve space may be utilized in many ways and may prove to be of value in the solving of many practical problems associated with the growing of crops. We suggest the following studies:—

(1) How Thick should Oats be Sown?

Experiment.—Prepare three plots of equal size, side by side, and plant oats in the first one 3 inches apart each way, in the second 5 inches apart each way, and in the third 7 inches apart each way. Cover each plot by sprinkling soil over the surface. Do not use a rake to cover lest you disturb the planted grains. Let all plots grow to maturity. Compare the amount and quality of the grain from each plot, also the length and quality of the straw. If the size of the plot be considered, the number of bushels per acre can be calculated easily. What is the greatest number of stems that you can find growing from one seed in any of the plots? In which plot do you find the greatest number of stems coming from a single seed? In which plot do you find the type of plant which is most desirable and which is defined on page 9, Part II, of this booklet? From this experiment make an estimate of how much oats you think should be sown on an acre to get the best returns.

(2.) How Deep should Oats be Sown?

Experiment.—Divide a plot into four parts. In the first part plant oats not more than half an inch deep; in the second an inch and a half deep; in the third three inches, and in the fourth five inches. Make a record of the growth observed in each part each week for three or four weeks. Which part looked best at the end of the fourth week? Would the nature of the soil have anything to do with the result? Would the results be the same for a wet season as for a dry one? Devise experiments to show this.

(3.) Many Farmers make a Practice of Cutting Oats a little on the Green Side. Is this a good practice?

Experiment.—Sow two plots of oats of equal size on the same day using the same amount of seed for each. When they show the *first signs* of ripening, cut one of the plots but let the other ripen completely before cutting. When perfectly dry thresh out the oats from each plot by hand and weigh them, putting the grain from the first plot in one jar and those from the second plot in another jar. Which weighs the heavier? Examine the grains carefully with a magnifying glass. Remove the hulls and examine the kernels inside. Cut some of the kernels in two and examine them internally. Select one hundred grains from each jar and plant them in two rows, side by side, in the garden the following spring. Have the seeds of each row equal vitality and do they produce plants of equal vigor?

(4.) Is there anything to be gained by Rolling the Ground after Sowing Oats?

Experiment.—Prepare two plots of the same size, spading them eight or ten inches deep and leaving the soil quite loose. Sow the oats in drills and cover very loosely and about an inch deep. Compress the soil on one plot by laying a board across it and pounding it down with a heavy block of wood or other device until the whole plot has been made firm. Allow the other plot to remain loose. On two or three successive days take the temperature of the soil in each plot one inch deep and three inches deep, using an ordinary thermometer. Which plot is the warmer? In which did the oats come up first? In which did they look the best after a couple of weeks? Which plot gave the better yield?

(5.) What is the Best Variety of Oats to Grow in your District?

Experiment.—Pupils may bring samples of different varieties of oats from their homes or elsewhere. For the sake of comparison the teacher should write to the nearest Experimental Station and secure a sample of one or two of the most highly recommended varieties. As many small plots should be prepared as there are samples of oats to test. Plots must be uniform in size and should be at least 9 feet long by [illegible] feet wide. Care should be taken in weighing the oats so that equal quantities will be sown on each plot. Each plot should also be planted in exactly the same way and if possible on the same day.

Note the progress in growth made by each variety, the date when ripe, the yield of grain and the quality. Should any variety in this test prove noticeably superior to the others the seed from it might be kept for further improvement on the regular plots, samples being given as foundation stock to new beginners. This experiment must be undertaken without prejudice as to what variety is best.

(6.) Many Farmers Sow Oats before the Ground is Cultivated Finely. Is this a Good Practice?

Experiment.—Mark out two plots of equal size, side by side, spading each six to eight inches deep, leaving the ground rough. Work one of the plots down very finely with a steel or iron rake, but give the other very little cultivation. Sow the oats in drills about one inch deep and cover loosely without compressing the soil. In which plot did the oats first come up? In which did they look better after a couple of weeks? Which gave the better yield?

II.—Laboratory Studies.

A.—The Soil.

(1.) What it is.

Ordinary garden soil is composed of two kinds of matter, (*a*) Organic, composed of decayed vegetable and animal matter; (*b*) Inorganic, composed of small particles of disintegrated rock. Pure sand and clay are entirely inorganic, whilst muck or humus is largely organic. Sand with a little clay and humus is called sandy loam; clay with a little sand and humus is called clay loam.

(2.) What Proportion of the Soil of your Garden is Organic and what Proportion Inorganic?

Experiment.—Weigh out and also measure a pound of soil from the garden, place in a pan and dry thoroughly in an oven. Weigh the dry soil and make a note of the weight of water given off, as this information will be found useful in a later experiment. Place the dry soil on a sheet of tin, copper or iron, and heat until red hot and until no more smoke comes off. Cool and weigh again. The residue is the inorganic or mineral part, the organic part having been driven off in the form of gas and smoke. What percentage by weight of the dry soil was organic? What percentage inorganic? Usually so-called "rich" soils have a high percentage of organic matter or humus.

(3.) What Percentage by Weight of the Soil in your Garden is Water?

Experiment.—Having noted in the last experiment the volume of a pound of soil taken from the garden and the weight of the water which it lost in drying, answer the following questions: How many pounds of water does a plot 3 feet square by 3 feet deep contain? How many gallons does it contain? At this rate how many barrels of water could be taken out of your whole garden, if the soil were thoroughly dried to the same depth? (Growing plants get their water from more than three times this depth in the earth.) At the same rate how many tons of water would one acre of such soil, three feet deep, contain? How many gallons of water would fall upon a plot 3 feet by 9 feet during a rainstorm that resulted in half an inch of water on the level? How many tons would that be per acre? If the average annual rainfall be 40 inches, how many gallons would a plot of the above size receive? These are examples of how arithmetic may be made more meaningful and practical when co-related with school garden problems.

(4) What kinds of soil are to be Found n your Locality?

Experiment.—Have the pupils bring samples of soil from their fields at home. Compare these samples with the soil of the garden and also classify them by comparing them with standard samples of coarse and fine sand, clay, humus, clay loam and sandy loam.

(5.) What Kind of Soil can Hold the Greatest Amount of Water?

Experiment.—Take samples of pure sand, pure clay, humus and a sample of the soil from your garden. Dry each thoroughly. Take four large glass tubes a foot or more in length (small Argand lamp chimneys will do nicely), tie a piece of thin wet cotton over one end of each, number and weigh them. Fill No. 1 with dry sand, No. 2 with dry clay, No. 3 with dry humus and No. 4 with dry soil from the garden. Weigh each again and record the weight. Stand each of the four tubes in a dish containing water so that the cotton is beneath the surface. Observe the water rising up through the soil inside the tubes. (The water rises between the pores or spaces in the soil by what is called "capillary attraction.") In which does it rise most rapidly? Does it reach the top in each? When the soils have taken up all the water they can, remove the tubes from the dishes of water, allow them to drain off for a few minutes and then weigh each tube. Reckon the percentage gain in weight of each. This will indicate the water holding capacity of the soil which each tube contains. The experiment may be varied by measuring the amount of water taken up from dishes of equal size by each tube.

(6.) What is the Value of the Soil Mulch?

Experiment.—Take four lamp chimneys and close one end of each. (Glass fruit jars would do, or even sap buckets.) Fill each to within three inches of the top with moist soil and press it down. On the surface of No. 1 put about 3 inches of sawdust, on No. 2 about 2 inches of loose soil, in No. 3 plant a dozen grains of oats and cover with soil 1 inch deep and leave No. 4 without anything. Weigh them and then set all four in the window. Keep the soil in No. 2 stirred up to a depth of one inch, but do not disturb the others. No water should be given any of them. Weigh them again at the end of a week. Which lost water most rapidly? Which retained water best?

By keeping the top soil in the garden fine and loose by frequent shallow cultivation the little channels in the soil through which water escapes by evaporation are broken up and the moisture is said to be conserved in the soil. This top layer of fine loose soil is called a *soil mulch.*

(7.) Does the Oat Plant Grow any Better in Well Drained Soil than in Soil that is Poorly Drained?

Experiment.—Take a large sized porous flower pot with a hole in the bottom. Put bits of broken brick or charcoal in the bottom to a depth of one inch, fill the pot with soil from the garden and plant oats in it. Then take a tin can of about the same size, but without an opening in the bottom or any broken material such as that placed in the flower pot, and fill it with the same kind of soil and plant oats in it. Water each thoroughly, giving each the same amount of water. Observe the growth for a week or two. Which produces the better plants?

The soil in the can is poorly drained and soon becomes water soaked. We know that roots need air and that very wet soil has but little air in it, so that plants like the oat plant cannot grow well in such soil.

(8.) How does the Oat Plant get its Food from the Soil?

We learned in Part I of this booklet that when the tiny plantlet, which lies wrapped up in the seed, begins to grow it first sends little rootlets down into the soil. If you examine these rootlets you will find many delicate, short hair-like tubes growing upon them. Each root hair is really a little hollow sack or tube like the finger of a glove. These root hairs can take in from the soil, water which has mineral matter [illegible] in it, and this helps to nourish the growing plant. This strange action of root hairs is called *osmosis* and may be shown on a large scale as follows:—

Experiment.—Place a hen's egg in a weak acid until the shell is dissolved away, then make a small opening in one end of the egg. Through this opening pierce the yolk with a bit of wire or a wood splinter, let the contents run out and then fasten this little membraneous sack to the end of a glass tube one foot long, putting the end of the tube into the opening in the sack about ½ of an inch and wrapping it firmly with strong thread. Fill the egg sack with a strong solution of sugar and water and set it in a large tumbler containing fresh water. In a few moments the fluid on the inside will be seen to rise up and overflow the tube, showing that some of the water in the tumbler went through the egg membrane into the sack. In the same way a plot of growing oats takes up several quarts of the soil water every day.

(9.) What Becomes of this Soil Water?

Experiment.—Take one of the smaller pots of oats that have grown four or five inches high. Water it well, set it in a warm sunny window and invert over it a large glass jar for a few hours. What do you find on the inside of the jar? Where did this water come from?

We have learned that the water which was taken in through the root hairs by osmosis is given off through the leaves, by what is called *transpiration.* The mineral water is used up in the plant in helping to build up new plant tissue. In a very strange way that no person has yet been able to explain fully, part of this soil water combines with the carbon dioxide of the air which the leaves take in and new plant substances are formed, some of which are starch, sugar and cellulose or woody fibre. These plant substances are made only when the plants are exposed to the sun's rays and this is why we said that the plots must not be in the shade of trees or buildings.

(10.) In what kind of Soil does the Oat Plant Grow Best?

Experiment.—Take four six-inch flower pots and put pieces of broken brick or charcoal in the bottom for drainage. Fill one pot with pure sand, another with clay, another with black muck or humus and the last with a mixture of equal parts of sand, clay and humus. Plant a dozen oat grains in each pot one inch deep and observe the progress of their growth week by week for a month. Give each pot the same amount of water. In which pot were the plants ahead at the end of a week? Two weeks? Three weeks? Four weeks? etc.

B. THE SEED.

(1.) What it is.

When we pick up a handful of oats and look at the grains it is indeed hard for us to realize that lying imprisoned in each seed, as was stated at the first of this booklet, is a miniature sleeping plant. The only way to bring your pupils to realize how true this is, is to have them examine carefully dry seeds, then seeds that have been soaked in water and finally seeds at different stages of germination. We know that all growing things, animals as well as plants, need food and protection and this is particularly true when they are young and in an immature condition.

Experiment.—Let the pupils examine the oat grain and find out what protection nature has provided for the embryo oat plant. The hull of the oat is its protection. Let them remove this hull from some soaked oat grains and see if they can find the little plant inside the kernel. They will discover that the tiny embryo plant makes up but a small part of the oat kernel and that most of the kernel consists of food matter that has been stored up around the embryo to protect and nourish it when the conditions for growth become favourable.

(2.) What does this Food Material consist of?

The pupils may already know that some grains like rice and corn have a very large proportion of starch and that they are used in the manufacture of the starch of commerce.

Experiment.—Crush a few of the dry oat kernels and moisten a little of the meal or flour with a drop of iodine solution. The dark blue colour which results is a proof that there is a large proportion of starch in the oat kernel.

Another important food material found in the oat kernel is protein or gluten. It is very valuable in the building up of tissue in the animal body and its presence in the oat kernel in fairly large proportions makes oatmeal a most nutritious food.

Experiment.—To prove that the oat kernel does contain protein, put a little of the meal in a test tube, add some hot water and a few drops of Millon's reagent (made by dissolving some mercury in strong nitric acid), and boil. A reddish colour appears which is proof that protein is present.

A third important food material contained in the oat kernel, though not in such large quantity as starch and protein, is oil or fat. The students already know some seeds which are very rich in oil, as cotton seed and linseed. The oil in oat grains may be detected by the following method:—

Experiment.—Take the hulls of a few oat grains, place the kernels on a piece of thin white paper on a smooth sheet of iron and heat in an oven, taking care not to scorch them. While hot crush the kernels on the paper by striking them with a hammer, then heat the paper again and examine it for the oil stains.

It is a noteworthy fact that every time we eat bread, pastry or cereals we are using the food that nature provided for those tiny plants, one of which, as we have said, every seed contains.

(3.) How does this Growing Plantlet use this Food which is Stored in the Oat Kernel?

All food must be in a soluble form before it can be utilized in the growing tissues. In all seeds there is a substance called diastase that acts on the stored food in the seed changing it to a soluble form. As the little plant begins to grow, the starch which surrounds it is changed into a kind of sugar. This can be shown as follows:—

Experiment.—Take some oat grains that have been germinating for a few days, remove the hulls, and dry and grind the kernels into a powder. Then add a little hot water to this powder in a test tube. Stir it for a few minutes and drain off the water into another test tube. Add a small quantity of Fehling's Solution to the water in this second tube and boil. The appearance of an orange to reddish brown colour proves that glucose, a kind of sugar, is present. (Fehling's solution can be bought at any drug store or can easily be made in any school laboratory as follows:—Take three bottles, A, B and C. In bottle A put 3 grams of copper sulphate (blue vitrol) and 100 cubic centimetres of pure rain water; in B put 16 grams of Rochelle salt and 100 C.C. of water, and in C put 12 grams of pure caustic soda and 100 C.C. of water. Take 5 C.C. of solution A and the same out of B and C, mix them and add 10 C.C. of water. This is then ready for use and should be used the same day that is is mixed.)

NOTE.—Common table sugar will not give the brown colour, but it can be changed to glucose by boiling it with a little sulphuric acid and water and then neutralizing it with some caustic soda after which it will give the brown colour with Fehling's Solution.

(4.) Under what Conditions will Oat Seeds Germinate and Grow Best?

The answer has been already given to this question in Part I. The students should now prove it experimentally as follows:—

Experiment.—Plant two pots of oats, water them thoroughly, set one in a warm, bright room and the other in a cold but well lighted place. Observe the growth of each and report after two weeks.

(2) Plant two pots of oats, as before and place them side by side in a warm bright room. Water one of the pots regularly twice a week but give the other no water. Report in two weeks.

(3) Plant two pots of oats, and set them side by side in a warm room. Water them both regularly, but exclude the light from one by inverting over it a tin pail or other opaque vessel. Allow air to get in around the bottom. Report in two weeks.

(4) Plant a pot of oats in soil from the garden and also one using wet clay mud in a tin can, tie thick paper or sheet rubber over the top of the can to prevent air from getting in. Can plants grow without air? Clay mud has very little air in it. If these experiments are carefully performed they will show conclusively that growing plants require *heat, moisture, light and air.*

HOW TO GERMINATE SEED FOR CLASS STUDY.

For germinating seeds indoors for class study the following method will be found convenient: Take a common soup plate and fill it half-full of moist sand. If the seeds are small spread a piece of wet cheese cloth over the sand and then scatter the seeds thinly over the cloth. Spread another piece of damp cheese cloth over the seeds and spread over it again a cup full of dry sand. To prevent too rapid evaporation cover the plate with a pane of glass or with another plate inverted. The seeds can be examined simply by lifting up the cheese cloth cover. Seeds may also be germinated in soil, in fine damp moss or moist sawdust.

(5.) As the Oat Grains begin to Grow what Changes do you Notice?

The pupils should make a careful examination of the oat grains at different stages of germination and drawings should be made showing first the developing caulicle, the lower end of which becomes the radicle or root; second, the delicate plumule or shoot that grows upward and becomes the stem. They should examine with a good magnifying glass or microscope the hairs that form on the delicate rootlets, the first leaf and afterwards the so-called "joints" which are simply thickened places where the bases of the leaves are attached. They will notice that the oat plant has one leaf for every "joint." When the plant heads out and its flowers open they should be examined carefully and drawings made of them, special attention being given to the reproductive organs—stamens and pistil—and how the pollen grains from the stamens get on the top of the pistil, fertilize it and produce the seed. With advanced pupils artificial hybridization in plants may also be discussed.

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